Water and biofuel

Extensive research hopes to answer - Should we 'grow' our future fuels?

Are biofuels the answer to an energy-scarce future? Do we have enough water resources in order to grow biofuels? These are some of the questions an intensive research project, led by the University of KwaZulu-Natal (UKZN) and funded by the Water Research Commission (WRC) aimed to answer.

Article by Kim Trollip.

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Biofuels remain a viable option in South Africa, despite being a water-scarce country – but there are a number of provisos. For example, we need to cultivate sustainable, water-efficient feedstocks and make viable decisions regarding land use change. Land use change that threatens the cultivation of food, or has a negative impact on biodiversity, or significantly reduces the availability of water to downstream users, should certainly be avoided. This is the conclusion of an eight year-long study that will guide amendments to existing biofuel-related policy, as well as help the biofuels industry plan the way forward.

The project has ensured that more precise knowledge is now available on water use and what biofuel crops can be considered (based on highest water use efficiency), the geographic location of suitable production areas for each crop and potential impact on streamflow reduction. Producing crops for biofuels is definitely still an option, with crops for bioethanol being more water use efficient. The study has also concluded that water availability (and not land availability) will determine limits for biofuel production potential in rain-fed areas of South Africa.

Within the innovation cycle, research on water use of biofuel crops was initiated through a scoping study. Following the determination of a wide range of potential crops, more detailed research was done on a range of variables influencing water use and the impact on run-off with rain-fed production of priority

Sugarbeet was one of the crops studied during the research project.

bioethanol and biodiesel crops. During the third phase of research, attention is now being given to water use and related agronomic practises with budgets of income and expenditure per hectare for advising emerging farmers who are interested in including these crops in farming operations.

WRC Executive Manager for Water Utilisation in Agriculture, Dr Gerhard Backeberg, urges actors in the public and private sectors to study the available research output in order to improve the biophysical basis for a sustainable biofuels industry in South Africa.

Principal investigator on the project, Richard Kunz, who is a hydrologist at UKZN, says the biofuels industry has the potential to bring underutilised arable land back into production, particularly in rural areas. He adds that the industry will also provide an alternative market for certain crops.

"For example, the expected demand for grain sorghum will encourage farmers to grow this crop. This will help reverse the declining trend in sorghum cultivation over the past decade. The Provisional Growth and Development Plan for KwaZulu-Natal (UKZN) highlighted the need to expand agriculture by almost a million hectares by 2030. The biofuels industry will certainly assist the provincial government in reaching this goal."

The study has also delivered a decision support tool to determine the impacts of biofuel feedstock production on water quantity.

Key messages to stakeholders

The project output will benefit different end-users in various ways. It will assist the Department of Energy (DoE) to revise the country's biofuel production potential; the Department of Water and Sanitation (DWS) to assess the streamflow reduction potential of selected feedstocks in sub-catchments; and it will help biofuel manufacturers to identify and target areas where feedstocks should be cultivated and the preferred location of processing facilities by using the land suitability maps. The knowledge is of great use to agricultural extension officers to advise emerging farmers on which crop is best adapted in a particular farming region. Water use planners can now be guided by water use efficiency estimates of crops towards making the most beneficial use of available water resources.

Produced as part of the study, the maps showing the inter-seasonal variability in simulated crop yields are useful in determining the risk of crop failure, which both farmers and the insurance industry may find beneficial.

Six private companies have already approached the DoE with proposals to set up biofuel manufacturing plants in South Africa, according to Kunz. Collectively, these companies would be able to produce some 1.3 billion litres of biofuel annually – three times the conservative target of 400 million litres initially suggested by the Biofuels Industrial Strategy back in 2007.

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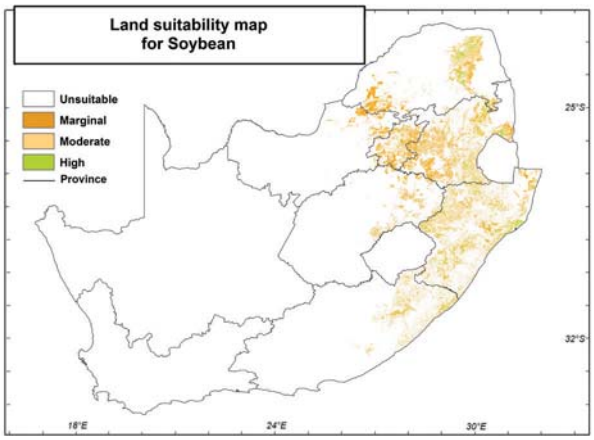
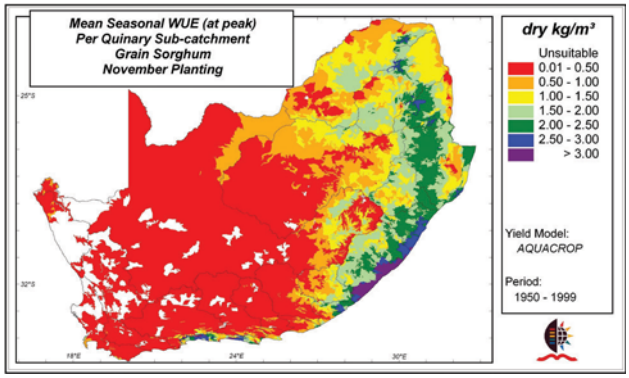


The report produced a number of maps to indicate the water and land suitability for the production of biofuel crops. This map shows the land suitability for growing soybean.



Looking at water use, sugarbeet is best grown along the east and southern coast of South Africa.

Kunz believes the strategy is overdue for revision and recommends that the Biofuels Task Team (responsible for revising this policy document) take cognisance of the research findings contained in the studies funded by the WRC. "Policymakers should promote the sustainable production of biofuels in South Africa. Foremost, feedstock should be cultivated under rain-fed conditions. In the Cradock region, the planned irrigation of grain sorghum and sugarbeet for biofuel production needs to be re-evaluated. Irrigation water should rather be used for food and feed production, not fuel production."

"The highest priority areas for poverty alleviation and rural development exist in KwaZulu-Natal and the Eastern Cape. Thus, biofuel-related policy should encourage and incentivise the use of currently unproductive arable land in these two provinces, for feedstock cultivation. Furthermore, the use of highly productive arable land for biofuel production is not recommended. Such land should rather be used for food production."

Biofuel policy needs to cap or limit the volume of biofuel production in South Africa. The higher this target volume, the greater the impact on the country's available land and water resources. South Africa's biofuel production potential is limited by the need to minimise the impact of large-scale feedstock cultivation on the country's water resources.

More effort is required to remove existing barriers which prevent smallholder farmers from participating in the biofuels supply chain. For example, other research at UKZN has shown that South Africa's current Cooperatives Act needs to be amended to allow private investment in traditional producer-owned cooperatives. This is deemed important if smallholder farmers are to participate in the biofuels supply chain.

Rolling out biofuels in South Africa: considerations

The petroleum industry has stated that compared to bioethanol, it is easier and cheaper to blend biodiesel into the fuel supply chain. However, the research shows that biodiesel production in South Africa requires far more land area than bioethanol production. For example, an additional 3 000 ha of land is required to cultivate sufficient feedstock to produce 1 million litres of biodiesel from soybean (i.e. 3 180 ha), compared to the same volume of bioethanol produced from sugarcane (i.e. 180 ha). Thus, if the availability of arable land in a particular region or province is limited, then the cultivation of bioethanol feedstocks should be preferred. To meet the feedstock production and supply demands, the companies would require a total area of arable land of 2.3 million hectares. According to a 2012 Department of Agriculture report, South Africa has about 2.5 million hectares of underutilised arable land.

"From the research to date, we now know that, to be sustainable, biofuel feedstock production must take place only under rain-fed conditions, and these crops must be grown in rotation with food crops such as maize and wheat," says Kunz. "With the support of training and resources, the production of biofuel feedstocks must also be promoted in rural areas where agricultural crop production is non-existent or sub-optimal. The production of these crops must strive towards the most beneficial use of available water resources."

The research also shows that some crops are more efficient users of water than others. For example, crops that contain sugar (e.g. sweet sorghum) are more water use efficient than feedstocks that produce starch (e.g. grain sorghum). In addition, the water use efficiency of sugar crops (e.g. sugarbeet) is much higher than crops that produce vegetable oil (e.g. soybean). The study maps highlight the spatial variability in water use efficiency, which may help to guide land use planners in striving towards the most beneficial use of the country's available water resources.

The reports highlight two crops which may negatively impact the availability of water to downstream users, especially if grown on a large scale in catchments that are already water stressed. Thus, the DWS will find the database of simulated reduction in streamflow generation useful in deciding which crops may need to be declared as stream flow reduction activities.

The researchers also looked at areas of South Africa where biofuel feedstock would grow under rain-fed conditions. They found that large parts of Mpumalanga, KwaZulu-Natal and the Eastern Cape were best suited to sugar beet planted in September, where at least 6 t/ha dry matter production was attainable. According to Kunz, a coastal section of the

Eastern Cape would yield the "largest crop per drop" of 2 kg to 2.5 kg of dry matter production per cubic metre of water used. However, sugar beet is particularly prone to fungal disease when cultivated in hot and humid areas.

Biofuels timeline:

2005	Cabinet approves the development of a strategy to create jobs through biofuels
2006	A feasibility study, conducted in preparation for the development of the National Biofuels Industrial Strategy (BIS) noted a likely increase in pressure on water resources from energy crops and called for more research by the WRC into the effect of commercial and small-scale biofuels production on both water quality and quantity prior to the roll-out of the strategy
2007	Government releases BIS and targets 400 million litres of biofuel production within five years
2007	WRC begins scoping study into biofuels, producing data on water use and growing conditions of some biofuels crops and highlighted areas where knowledge was lacking
2009	WRC launches dedicated, multi-million rand biofuels study to assist the Department in assessing the potential impact of large-scale feedstock production on water resources
2009	The (then) Department of Water Affairs and Forestry releases a statement highlighting the fact that South Africa is a water-scarce country which can ill afford the use of current or potential irrigation water for fuel production rather than growing crops for food
2010	Worldwide biofuel production reaches 105 billion litres
2012	National target of 400 million litres of biofuel as captured in the BIS is not met, but government announces that that the petroleum industry must blend a minimum of 2% of locally produced bioethanol into its petrol from October 2015 onwards
2015	WRC completes R7,4 million research project to determine the water use and production impact of various feedstocks suitable for biofuel production in the country
2016	In July, an SAA flight from Johannesburg to Cape Town was powered by petroleum-based jet fuel blended with biofuel. The biofuel was derived from the oil of nicotine-free tobacco plants grown by farmers on underutilised land in the Limpopo province
2015	The WRC funds another research project that will run until 2020 to develop agronomic practices for best production of biofuel crops by emerging farmers, as well as the economics of producing these feedstocks in rural areas.
2050	International Energy Agency goal for biofuels to meet more than a quarter of world demand for transportation fuels

The potential for biofuels in South Africa

Bioethanol and biodiesel can be blended with petrol and diesel, reducing dependency on fossil fuels. The sugar and starch extracted from feedstocks are converted into bioethanol, and the vegetable oil into biodiesel. A valuable by-product is animal feed. About 1 t of sugarcane can be used to produce 80 ℓ of biofuel and 280 kg of bagasse; 1 t of grain sorghum can be used to produce 417 ℓ of biofuel and 221 kg of animal feed.

Looking ahead

The WRC has funded 13 years of biofuels research. The initial scoping study (2007-2009) focused on the feasibility of biofuel production and highlighted potential feedstocks. The scoping phase was followed by the research phase where the WRC initiated and funded a more detailed 6-year study (2009-2015).

This is now being followed by the implementation phase, where the WRC is funding an additional five-year study (2015-2020). This project considers the economics of feedstock production by smallholder farmers, as well as developing guidelines to advise emerging farmers on agronomic practices of feedstock cultivation. It focuses on two feedstocks in particular, namely grain sorghum and soybean, selected by the DoE as reference feedstocks to determine the pricing framework for bioethanol and biodiesel production.

Grinding of sweet sorghum stems as part of the biofuels study.